REPORT RESUMES

ED 003 741 64
INSTRUMENTATION FOR INSTRUCTION, 1955-70, VOL. 4--TEXT.
BY- FINN, JAMES D.
NATIONAL EDUCATION ASSN., WASHINGTON, D.C.
REPORT NUMBER NDEA-VIIB-069-4 PUB DATE 60
EDRS PRICE MF-$0.18 HC-$4.04 101P.

DESCRIPTORS- *EDUCATIONAL EQUIPMENT, *INSTRUCTIONAL AIDS, AUDIOVISUAL AIDS, COMPUTERS, ANALOG COMPUTERS, DIGITAL COMPUTERS, INSTRUMENTATION, DISTRICT OF COLUMBIA, TECHNOLOGICAL DEVELOPMENT PROJECT

INFORMATION FOR PLANNERS OF NEW SCHOOLS AND INSTRUCTIONAL SYSTEMS ON EDUCATIONAL INNOVATION, AND ON PRESENT TRENDS FOR SCHOOL TEACHERS, PRINCIPALS, AND ADMINISTRATORS WAS PRESENTED. THIS VOLUME INCLUDES SECTIONS ON COMPUTERS AND AUTOMATION, GAMING AND SIMULATION, AND THE SCHOOL OF THE FUTURE. OTHER VOLUMES IN THIS SERIES ARE ED 003 738 THROUGH ED 003 746. (LP)

ED003741

069

FINAL REPORT

TECHNOLOGICAL DEVELOPMENT PROJECT

INSTRUMENTATION FOR
INSTRUCTION: 1955-1970

Draft Copy for Editing

VOLUME IV - TEXT

U. S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
Office of Education
This document has been reproduced exactly as received from the person or organization originating it. Points of view or opinions stated do not necessarily represent official Office of Education position or policy.

IX

For Library + Classroom

COMPUTERS ~~AND AUTOMATION~~

A. INTRODUCTION

Computers are symbol manipulating devices derived from adding machines and desk calculators. Using electronic circuits, the modern computer can solve a problem millions of times faster than its mechanical predecessors. There are two basic types of computer, the analogue and the digital. The analogue computer deals with relative values along a continuum, and is useful mostly in science and engineering. the analogue computer lacks the precision of ~~T~~the digital computer uses discrete numbers to solve any problem which can be expressed in mathematical or logical form. The digital computer is causing widespread excitement because of its potential for saving time, ~~and~~ money, and human effort. It has also proved invaluable as a research tool, and is widening the frontiers of human knowledge.

1. Purpose.

Digital computers are of potential value to schools for accounting, payroll, inventory, and scheduling and handling of student records. The same computer could simultaneously be used for library, teaching machine, simulator, and gaming activities. The digital computer is invaluable for processing statistical data, and for direct research in fields such as artificial intelligence. The extensive adoption of computers by business, industrial~~,~~ and military organizations, and by some of the larger colleges, would seem to indicate their possible use by schools in the near future.

2. History.

The origins of the modern digital computer can be traced back thousands of years, but the modern development began early in the seventeenth century with Pascal's adding machine, which also performed multiplication by repeated adding. Babbage began work in 1812 on a machine to square functions (x^2), and other devices were subsequently developed for higher mathematical processes such as integration and differentiation. In 1886 Hollerith introduced punch cards as a method of storing and sorting information to facilitate counting of the U.S. Census, and this led to the development of card-sorting machines by International Business Machines and Remington Rand. These machines also proved useful for adding, subtracting, multiplying, sorting, listing, collating, and reproducing, so that the era of modern data processing was born.

Punch cards can be equated to a binary number system since for any position on the card there are only two possibilities, punch and no-punch. Stibitz, of the Bell Telephone Laboratories, applied this same principle to electronic circuits in 1939 to produce the first electric digital computer. Here the binary pair was represented by two possibilities, current on and current off. All numerical, mathematical, and logical problems can be ~~represented in~~ reduced to binary terms. Also, binary numbers facilitate the storage, processing, and transmission of information with great precision.

Stibitz's device used relays of the type used in a telephone system, but about this time work was begun by Aitken at Harvard in conjucntion with IBM to develop a large general-purpose digital computer, which was completed in 1944. The modern era began with the ENIAC built at the University of Pennsylvania, which used electronic tubes rather than relays to accomplish the switching functions. This unit had 18,000 vacuum tubes, cost $750,000, and operated on ten digit decimal numbers. Subsequent developments have been largely toward increased speed & efficiency, larger memories, and reduction in overall size. This has been greatly assisted by the introduction of transistors and magnetic core memories. The recent advent of molecular electronics will result in ~~a~~ further miniaturization. ~~reduction in size.~~

In twenty years of development the computer memory has increased from 20 words in the ENIAC to 100,000,000 words in the new IBM STRETCH. Also, the access time has decreased from 200 microseconds to the order of 1 microsecond. More than 12,000 computers have been built and installed by American companies in thi~~s period~~e past 15 years, ~~including units which rent for $500 a month to units renting for $300,000 a month.~~ Because ~~The fact that~~ computers can save businesses ~~money even at these high rentals~~

~~is an indication of the enormous data processing capability of the modern computer.~~

3. Functional Units of the Computer.

The principal difference between the computer and the desk calculator is the ability of the computer to store information, allowing it to perform a whole series of operations without human intervention. The instructions to the computer constitute a program, which is normally fed into the computer along with the data to be processed. The program and data are stored in the computer memory. The control unit interprets the program and regulates the operation of the arithmetic unit which performs the various data processing functions. The computer communicates with the outside world by means of the input and the output. The input is the means of feeding in the data and program; the output prints out the processed information. Although the educator is concerned principally with what the computer can do, some understanding of its functions will assist in the discussions to follow.

B. TRENDS AND DEVELOPMENTS SINCE 1955

Since 1955 computer technology has undergone considerable growth, assisted by a growing demand from industry and business, intensive research leading to some major breakthroughs, and a general increase in information processing capacity with a lowering of cost. Computers have become smaller and more efficient through the use of transistors, and very recently with molectronics (molecular electronics). Magnetic core memories have effected larger storage for less cost, again with reduction in size. New storage devices have been introduced, including magnetic tape, magnetic drums and discs, and image storage tubes. There has been a diversification of input and output devices to simplify the ~~accommodate~~ coding + interpretation of the data. ~~and to eliminate unnecessary labor~~ ~~direct input of information, or to reduce intermediate steps.~~ Also, ~~And~~ significant developments in programing techniques have lessened the amount of human labor needed to develop a program.

Computer operating speeds have increased in ~~by a~~ large measure ~~factor~~, along with their information handling capacity, so multiple inputs with "executive" scheduling enable the computer to work on several tasks concurrently, and thus operate to its full capacity. There has been a trend toward larger general purpose computers, with the development of special purpose units in all sizes. Despite its extensive development and use, the computer field is still very new, and its potential is unfathomed. The following sections will review the newer instrumentation and some of its present uses, but it can do little more than provide the reader with ideas ~~to~~ upon which to speculate. ~~upon.~~

1. General Purpose Digital Computers.

It is difficult to imagine how big business could function without the digital computer for accounting, billing, payroll, inventory, mailing lists, and statistical tabulation. Many smaller businesses, and even a few of the larger ones, are still using punch card equipment, which is the immediate predecessor of the computer. But ~~as the operation~~ grows, ~~the~~ economies ~~which can be effected with a full computer operation lead to changeover,~~ and in ~~the process many new capabilities~~ can be realized.

Most computers come in a series of modular units which allow~~s~~ the computer to be adapted more nearly to the user's needs. In this way additional inputs, storage, etc., can be accommodated within the limitations of the overall computer design. A typical system might have several punch card and ~~electric~~ typewriter inputs and one or two high-speed typewriters for output purposes. Table __ lists manufacturers and models of computers currently in production include ~~which rent from $500 a month to $300,000 a month.~~ The fact that time and money can be saved ~~at~~ at these rental~~s~~ prices is indicative of the enormous volume of information the computer can handle.

2. Special Purpose Digital Computers.

Sometimes a computer is needed for some specific kind of operation such as design engineering, or information storage and retrieval. Such ~~applications have~~ specific requirements which, ~~in many instances,~~ are ~~can~~ be more conveniently built into a special-purpose computer, which ~~They~~ may be quite small or very large depending on the operation involved. Most of the companies in Table ~~are active in~~ custom build~~ing~~ computers for special-

DTGITAL COMPUTERS CURRENTLY IN PRODUCTION

MANUFACTURER	NAME OF COMPUTER
Addressograph-Multigraph Corp.	EDP 900 system
Advanced Scientific Instruments	ASI 210 ASI 420
Autonetics	Recomp II Recomp III
Bendix (now Control Data Corp)	G-15 G-20
Burroughs	B250 B260 B270 B280 B5000
Clary	DE-60/DE-60M
Computer Control Co.	DDP-19 DDP-24 SPEC
Control Data Corporation	160/160A 1604 3600 6600
Digital Equipment Corp.	PDP-1 PDP-4
General Electric	210 225, 225, 235
General Intellitronics	I-85
~~General Dynamics~~	~~SC 1090~~
General Precision	LGP-30 RPC-4000
Minneapolis Honeywell Regulator Co ~~Honeywell Electronic Data Proc.~~	H-290 H-400 H-800 H-1800

Later
*

H-W Electronics, Inc.	HW-15K
HRB Singer Inc.	SEMA 2000
Hughes	H-330
International Business Machines	1401 1410 1440 1620 7040 7044 7070 7072 7074 7080 7090 7094 STRETCH
Information Systems Inc.	ISI-609
International Telephone + Telegraph ~~IT&T~~	7300 ADX
* → Minneapolis Honeywell	
Monroe Calculating Machine Co.	Monrobot IX Monrobot XI
National Cash Register Co.	NCR - 304 NCR - 310 NCR - 315 NCR - 390
Packard Bell	PB 250
Philco	2000 2400 BASIC PAC
Radio Corporation of America	RCA 301 RCA 501 RCA 601 3301
Scientific Data Systems Inc.	SDS-910 BDS-920
Sylvania Electric Products Inc	9400
Thomson Ramo Wooldridge	RW 530

UNIVAC Division, Sperry Rand	Solid State 80 Solid State 90 STEP Solid-state II 490 1107 III File Computers 60 120 1004
Westinghouse	Prodac 500

Based on table in Computers and Automation, December 1962, pp. 57-58.

Analog Computers

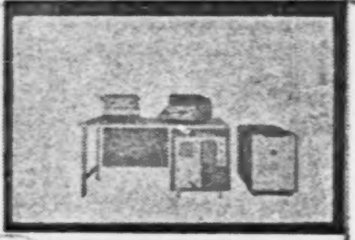
Applied Dynamics Inc
Beckman Instruments
Comcor Inc — Computer Systems Inc.
Donner Scientific Co.
Electronic Associates Inc
Epsco Inc. (Combined Analog & Digital)

Reeves Instrument
Systron Donner

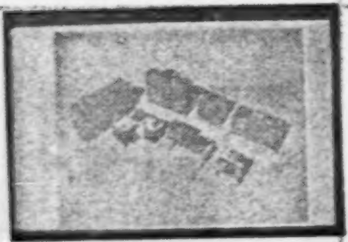
Computers

(520) Addressograph
EDP 900

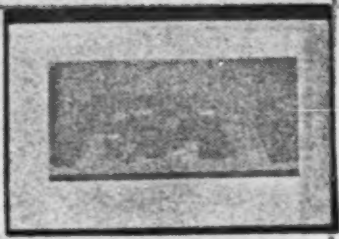
(525) Advanced
Scientific
Instruments
ASI 210 or 420



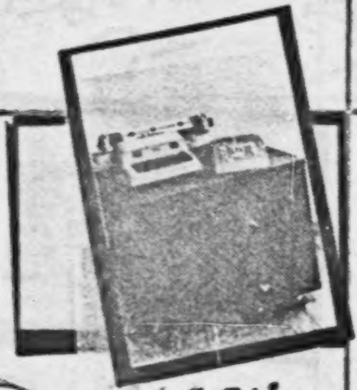
(522) Autonetics



(523) Bendix



(524) BURROUGHS

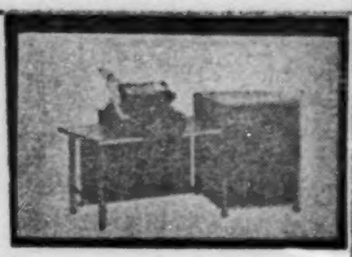


(525) CLARY

COMPUTER
(526) CONTROL
CO

CONTROL
(527) DATA
CORP

(528) DIGITAL EQUIPMENT Co



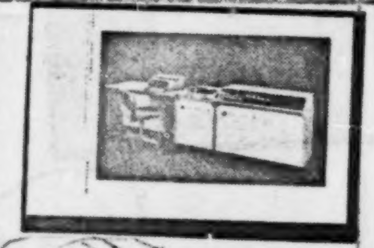
FRIDEN.
(530)

(531) GENERAL ELECTRIC
~~210 [illegible] 225~~

ESIAC
(529)

GENERAL DYNAMICS
~~PRECISION~~
~~SC 1090~~

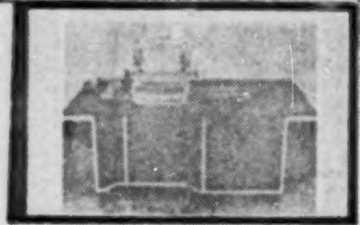
General Intellitronics
Model I-85
?



(532) GENERAL PRECISION

HUGHES

533a



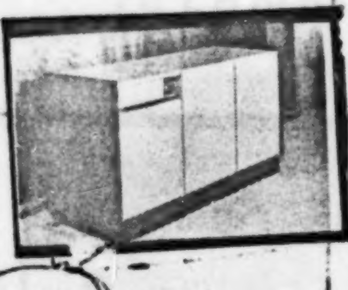
534a INFO. PRODUCTS CO.

(534) HW ELECTRONICS

(533)

HRB SINGER

(536) INTERNATIONAL BUSINESS MACHINES



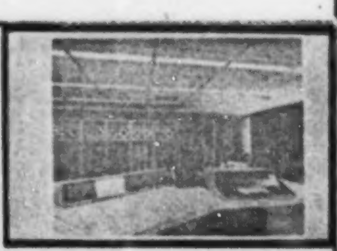
(535)

INFORMATION SYSTEMS INC

INTERNAT TELEPHONE & TELEGRAPH

MAGNAVOX

INFO SYS



(537)

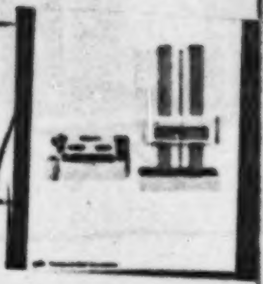
MINNEAPOLIS HONEYWELL

(538)

MONROE CALCULATING MACHINES

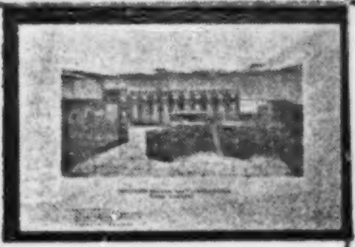
(539)

NATIONAL CASH REGISTER



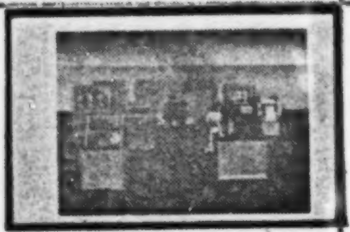
PACKARD BELL

(540)



PHILCO

(541)



(542) RCA

(543) SCIENTIFIC DATA SYSTEMS

~~(544)~~

~~SYLVANIA~~

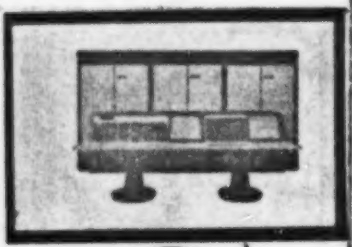
~~9400~~

ESIAC

THOMPSON
RAMO
WOOLDRIDGE

UNIVAC

(545)



(546)

WESTINGHOUSE

purpose application, and to this list should be added Aeronutronics, El-Tronics, Friden, International Telephone and Telegraph, Laboratory for Electronics, Rheem Electronics, and others. If analogue computers were included in this category, many more names would need to be added.

3. Programming and Computer Language.

To simplify the task of computer programming, compiler languages such as ARGOL, COBOL, etc., have been developed ~~to~~ which are subsequently tranposed by the computer into instructions and data in binary form. Even with these compilers the task of programming is long and arduous, and a complex program might take several months to develop. The time and cost is not consequential where the program will be used continuously. ~~but~~ The usefulness of the computer ~~would~~ is being ~~be~~ further enhanced ~~if~~ as the capability is developed to program itself ~~it could take over~~ more ~~some of the programming~~ to some extent. ~~steps, or even become self-programming~~. Present research is leading in this direction.

Sometimes ~~a program~~ written in one computer language must be transposed for use on another ~~computer, and for this~~

~~purpose special computer programs have been written which automate the process entirely. The next step is to develop programs to transpose the english language into computer language, which would open up the "self programming" capability. This involves not only the transposition of words but of meanings, so that the computer will need a large dictionary of words and idioms, and be capable of analysing sentences into their component words and phrases, and interpreting word relationships to determine the overall meaning. To build such a program is a highly complex task, made more difficult by the lack of well defined rules in the English language, and the number of exceptions to these rules where they exist. Some experimental programs of this type are now being developed, and present results are most encouraging.~~

~~In addition to language translation, a self-programming computer would need an extensive program in problem solving. At the present time it would take a month of work to develop a program to solve the problem of getting the 3 missionaries~~

~~and 3 cannibals across a river in a boat holding 2 people so that the missionaries are not unt-numbered and eaten. Some general problem solving programs are in process, and will eventually enable a range of quite difficult problems to be undertaken without the need for additional programming of the computer. Still one more facility is needed for a self programming computer to be successful. It must be capable of processing and assimilating new information, and of learning from its own mistakes. Such capabilities may seem somewhat improbable or fantastic at this point, but their relevance and value will become clear in later sections.~~

The problem of programming a computer can be likened to the task of a tutor communicating a process to his student. In reality the task is much more difficult since the computer has no background of experience, and no innate intelligence, so that even the most fundamental relationships must be spelled out in detail. Also, every proce~~s~~dure must be generalized so that once the computer can multiply 2 X 2, it can also multiply 222222 X 22222

The abilitymof the computer to work with extremely complex equations embodying hundreds of variables, and perform in minutes engineering calculations which would take ~~hxxxx~~ years of human labor, indicates that in mathematical areas at least, the computer is already highly proficient. The special demands of information systems, teaching machines, simulat~~ion,~~ers language translation, and artificial intelligence are now receiving increased attention. ~~Many of the experimental programs are designed for use with new kinds of input devices which enter the information into the computer more efficiently than human transcription using a typewriter,~~

~~1. Input~~

a. Input Devices. The possibility of entering information into a computer using a typewriter or key punch,

INVAC
IBM
Smith Corona

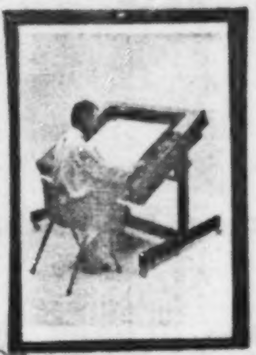


Fig. 547 X-Y Plotter and printout for analog and digital ~~[illegible]~~ computers where graphic or co-ordinate data is involved . (~~California~~ Computer Systems Inc ~~Computer Products~~)

punch cards, punch tape, or magnetic tape, has already been mentioned. More recent developments, which will be explained below, include graphic inputs, optical scanners, sound inputs, and some research devices involving the sense of touch.

(1). Graphic inputs include the X-Y plotter and the light pen. The X-Y plotter is a mechanical arm used to trace an existing drawing and in the process convert it into digital information for storage and processing. Such units have been developed by Aeronutronics, Autonetics, Brush, California Computer Products, Computer systems Inc, (547), ~~and~~ Itek Electronic Associates, Most of these are developed for specific applications such as battlefield control systems or transposing weather maps. The light pen is a device for writing directly on the face of a cathode ray tube, or ~~for~~ adding to or correcting information already displayed on the tube. Digital has such a unit for ~~their~~ its PDP series of computers, and Itek uses this unit in ~~the~~ its EDM Design and ~~(EDM)~~ Drafting System

(2). Optical scanners have existed since the early

Fig. 548 Matrix Analysis and Pattern Recognition. The computer is capable of relatively complex behaviors such as reading type-faces and even hand written numbers. The interpretation of handwritten materials would represent the ultimate development in this field. (IBM)

fifties, but have not been widely sought after until the last year or two. Printed information can be read directly with a scanner, and interpreted by the computer which compares each symbol or character against a standard set stored in the computer memory. For the most part, these scanners read only the ~~special~~ type fonts chosen or specially designed for them by their manufacturer, but ~~more flexible systems are being developed.~~ Their ~~principal~~ advantage over human transcription lies in their speed and accuracy in entering information into the computer ~~which~~ reduces both time and cost on large jobs. IBM has a machine which (for experimental purposes at least) can read several type fonts, or even hand-written numbers.(548) Optical scanners are available from Addressograph, Farrington Electronics, International Business Machines, and Rabinow Engineering. Several other companies have models ready for release, including Baird Atomic, General Electric, National Cash Register, and Philco, + UNIVAC. It should be noted that a special program is needed to interpret the information as read by the optical scanner.

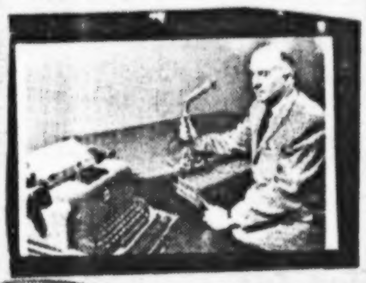


Fig. 549 Phonetic Typewriter.

Sound matrizes can likewise be analysed by the computer and compared with word syllables read in by the speaker beforehand. Printout is by the typewriter in the foreground.

Fig. (55) Computers usually work more rapidly than conventional typewriter printouts can handle. This device prints out 30,000 lines per minute by Xerography from a television display. (Benson-Lehner)

(3). Sound inputs from a microphone can likewise be analyzed and compared by the computer to identify the component words. Such applications require quite complex programs and an extensive computer vocabulary, but their feasibility has ~~never-the-less~~ nevertheless been demonstrated by Sony in Japan, International Business Machines, and Radio Corporation of America. Because of individual differences in speaking, these programs usually operate by matching the sound patterns with a set of word syllables read in by the speaker beforehand. Fig. 549 shows the ~~RAS~~ RCA unit, which also has a translation capability for foreign languages.

Fig.

(4). The sense of touch has been incorporated into an experimental program to explore the possible uses of a mechanical hand. This has been programmed to find, identify, an/ manipulate objects, performing such simple tasks as stacking

stacking blocks on top of one another or dropping them into a basket.

b. Output Devices. Conventional forms include the electric typewriters used for input purposes and high-speed electric typewriters such as the Analex are capable of printing up to 1,000 lines per minute. Photographic printout from a television display now increases this to 30,000 lines per minute in the Benson-Lehner unit (550). Other developments include X-Y plotters, electro-luminescent displays, large screen displays involving television projectors or an intermediate photographic step, electrostatic (paper) prints, and sound generators are available where required.

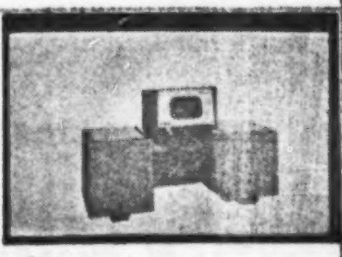
(1). X-Y plotters used for input can usually be used for plotting data from the computer.

(2). Electro-luminescent displays use a cathode ray or television tube to facilitate direct readout of the required information in written, graphic, or even pictorial form. Use of an electronic image storage device allows the

ELECTRO LUMINESCENT DISPLAYS

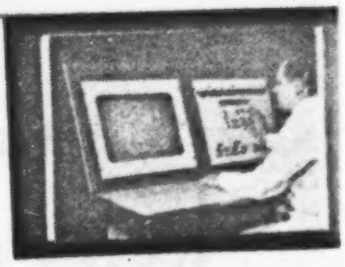
TACHDEN
Dm to Phot

AERONUTRONICS
(551)



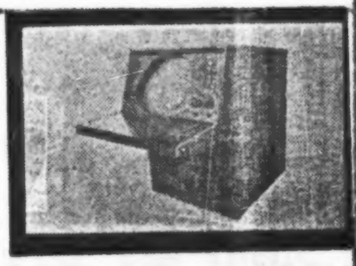
ELECTRADA
(555)

INFORMATICS

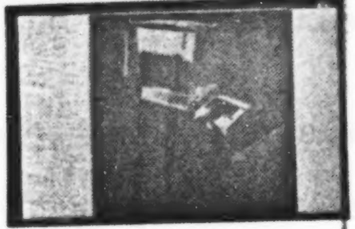


BURROUGH.
(552)

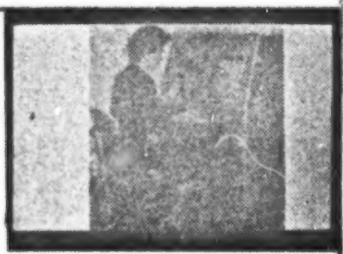
COMPUTER
CONTROL



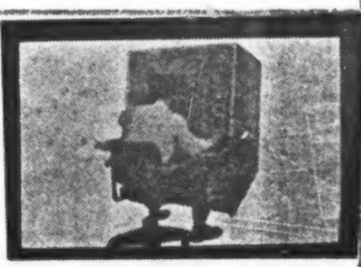
(556) GENERAL
DYNAMICS



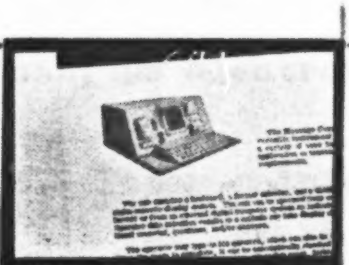
(559)
LABORATORY
FOR
ELECTRONICS



(553) A.B. DICK



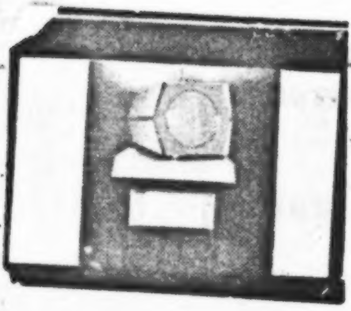
(557) GENERAL
DYNAMICS



(560) MARQUARDT

?

RECORDAK



DIGITAL
(554)

(558) INFORMATION
PRODUCTS.

(561) THOMPSON
RAMO
WOOLDRIDGE

computer to continue with other tasks until the display is ready for updating or replacement. Electroluminescent displays are supplied by Aeronutronics (551), ~~Computer Control~~ Burroughs (552), A.B. Dick (553) Digital (55 Electrada (555), General ~~Precision~~ Dynamics (556 557), Informatics (558), Laboratory for Electronics (559), Marquardt (560), and Thompson Ramo Wooldridge (561). In many instances, these are used in conjunction with the input typewriter or message composer for monitoring the input to the computer.

Sometimes the cathode ray tube is permanently set up as part of a camera recording unit, ~~or~~ electrostatic, or other kind of direct paper printout. Paper printers have been developed by A.B. Dick ( ), ( ) and Recordak ( ). Recordak also has a unit for microfilming ( ), and other companies have experimental devices for recording on Photo- or ~~T~~thermoplastic (General Electric), Kalvar ( ), and PCMI (National Cash Register).

need reference

(3). Large Screen displays ~~xxxxfinding~~ generated by a computer are finding increased use in the more elaborate military display systems, such as those used in battlefield control or in high level briefings. Ordinarily these use photographic projections of charts, maps, or other often-used data, supplemented by computer generated displays of current troop positions, identification of friendly and enemy troops, tanks, air power, etc. They have ~~also been~~ are used for tracking astronauts, artificial satellites, and missiles. Such units have been developed by Aeronutronics ( ), DuMont ( ), General Precision ( ), Informatics ( ), Marquardt ( ), National Cash Register ( ), and the Radio Corporation of America ( ).

New par?

Two rather unusual plotting devices should be singled out for mention here. Fenske, Fedrick, and Miller have a plotter which uses a servo mechanism to scribe lines and symbols on a small piece of film in a projector ( ) ( ). Although a computer is not a necessary part of the system, the plotting board ( ) can be used as a computer input using an analogue to digital converter. The National Cash Register system ( ) uses a display stored on PCMI, which can be permanent,

Check #

Fig. 553 Three Dimensional Viewer. A rapidly rotating phosphor screen and a cathode ray beam enable an image to be recreated in space. Such devices will probably be used to monitor the multi-level flow of planes around airports in the 1970's. (International Telephone and Telegraph.

Fig. 554 Another version of the 3-D viewer. It is used here as a readout mechanism from a computer (Avco)

Teleregister reference?

instantly erased, or faded according to a controlled time schedule.

④. Three-dimensional displays can be generated using the Fenske, Fedrick, and Miller unit with dual projectors having polaroid filters, with polaroid glasses for the viewer. This allows tracking of objects in three dimensions, and has many fascinating possibilities for the classroom. Another approach developed by AVCO (554) and International Telephone and Telegraph (553) uses an electron beam writing on a rapidly rotating vane of fluorescent material. This system has the advantage of requiring no glasses, but is more costly. Also, because it occupies three-dimensional space, such displays can be of limited size only.

⑤. Sound generators to synthesize music and voice have been developed by the Bell Telephone Laboratories, M.I.T., Radio Corporation of America, and the University of Michigan for experimental purposes. The first practical application is for supplying ticker tape information from a central computer at the stock exchange ______

⑥. Automation or the direct control of machines is yet another form of computer output. Milling machines carve three-dimensional components with accuracy and precision; boring machines drill a series of different sized holes with the accuracy of a template; assembly machines select, test, and assemble a series of components in automated production lines. Whether the job is writing out pay checks or turning out goods on an assembly line, sequential and repetitious tasks can now advantageously be delegated to computer control.

4. Data Processing Capabilities of Computers.

The term "data processing" is descriptive of a very wide range of operations which the computer can perform, including accounting and other business type operations, information storage and retrieval, language translation, gaming, simulation, and a host of control functions which could come under the heading of automation.

a. Business operations. Many tasks in business involve repatative proceedures, as with payroll where the formula (hours x times rate - minus deductions) is applied to hundreds or even thousands of sets of individual data; or in preparing mailing lists where obsolete names are deleted, new names added, and the whole alphabetised. The computer can take over such tasks very readily, and ~~effect~~ perform them with great speed and precision. Business operations for the computer fall into two general classifications, mathematical computation, and symbol manipulation.

(1) Mathematical computation includes accounting,

analysis. The accounting facility is widely used by banks, insurance agencies, and oil companies. This includes not only the balance sheets but billing, payroll, and inventory. The facility of the computer for correlating data enables it to update inventories or accounts, or to read out information on a specified item almost instantaneously on demand. Taxation, census, and various licensing operations are now being ~~converted~~ taken over by ~~to~~ computers.

The computer is used extensively in research for mathematical computation, and statistical analysis, and in some instances for data recording ~~in some instances.~~ It is possible to directly compute component dimensions from design parameters, whether it is the wing sweep of a supersonic airplane, or the characteristics of an optical system for viewing the planet Mars. Statistical analysis is being used for market surveys and predicting trends, for selecting personnel, ~~and~~ management decision making, ~~for~~ predicting voting returns, and even selecting marriage partners!

(2). Symbol manipulation includes indexing and inventory ~~type~~-operations which are not easily separated for description. These include/alphabeti~~s~~zing, sorting, selecting, matching, comparing, listing, and updating of lists and inventories. Typical examples ~~might~~ include preparation and updating of mailing lists~~,~~ or indexing publications for a large information system.

~~Some types~~ Many varieties of data processing machines are ~~already~~ used in schools, and a few schools are already using computers. Their immediate uses includes payroll, inventories, ordering supplies, and scheduling equipment. ~~They~~ Data processing machines have also been used to advantage in scheduling teachers and classrooms at the beginning of each semester. ~~Potentially~~ They are ~~of value~~ already used for grading test papers, keeping student records, and ~~sending out~~ preparing report cards. Data stored in the computer would also be instantly accessible for counseling purposes, and for teaching machine type operations~~ to be discussed later.~~

~~2.~~ Information Storage and Retrieval. Computers may be used as an index to a library system, or even store the documents themselves. Wherever time and accessibility

b. Mechanical Translation. Translation programs have existed since the inception of computers because of the need to translate programming languages into machine language for processing ~~computing purposes~~, and then translate it back into a form intelligible to humans for printout. The simplest example would be converting decimal into binary digits, and vice versa. This capability has been extended to coding letters of the alphabet, and interpreting machine instructions coded in the form of words. More recently it has been used to convert one machine language into another, and the latest development includes programs to translate English and foreign languages into computer language so that they might readily be converted from one to the other. Thus a computer might convert Russian text into intelligible English, or translate other languages such as French or Spanish. Figure shows a Russian to English translation made by a computer.

Fig. 555 IBM or Ramo Wooldridge translation

The translation of human languages involves problems beyond the matching of vocabulary. Grammar, syntax, and meaning are also important in obtaining an acceptable translation. Lexicographers have had to prepare very extensive dictionaries with alternative meanings, and the computer programs have concentrated on parsing and identification of key words. The National Science Foundation reports some twenty experimental projects in automatic translation presently underway in the United States, involving such languages as Chinese, Comanche, German, Japanese, Spanish, and Russian.

The translation facility is being still further extended by the use of optical scanners and their associated programs for identifying characters, ~~and~~ words, and sentences, so that printed text in Russian can be converted to acceptable if not entirely accurate text in English. Using a phonetic typewriter, spoken English could be converted to printed English, or even to printed German, Spanish, or French. It would even be feasible for spoken English to be converted into spoken Spanish, and so on, so that a wealth of ~~new~~

applications may one day be possible. Optical character readers might be used by archaeologists to translate Cuneiform and Hieroglyphs, by students of world history and politics, by military leaders, scientists, and archivists.

c. Automatic Abstracting. The ability of the computer to parse, identify key words, and rewrite sentences has been extended to the compression of language into abstract form. This includes written abstracts and word profiles. The preparation of written abstracts requires some degree of selection, and research into language structure has provided insights which now make this possible with a reasonable degree of success. For indexing purposes and selecting publications to match a reader's interests, key words or word profiles are proving more than adequate. The real importance of these developments will become apparent in the section which follows.

d. Information Storage and Retrieval. Modern libraries are beset with many problems. Growth adds to the problems of indexing, and as the volume of storage increases, retrieval of any particular document requires more time for both searching and physically transporting the book back to the user. Misfiling can cause a document to be lost for months, and a sizeable number of requests cannot be met because the book is already on loan. Any user of a large college or city library will appreciate the time lost waiting in line for books which are out on loan or cannot be found.

Computers promise to solve the problems of indexing, storage, searching, and retrieval, so that any document in the system can be made available instantly on demand. Furthermore, documents never leave the system and cannot be lost. Scores of different approaches have been developed for storage and retrieval, but usually storage involves some photographic medium, and retrieval involves searching reels of microfilm, stacks of cards, etc. In a large system television scanning speeds delivery of the document, and microfilm or electrostatic printing may be used for producing hard copy.

(1). Indexing and classification are achieved using key word and word profile methods discussed earlier. At the present time this is usually accomplished by human labor, and is very time-consuming. Computer indexing will overcome thi~~s~~ bottleneck of indexing so that new publications and documents can be immediately indluded in the system.

(2). Storage on microfilm would allow the contents of the Library of Congress to be housed in one large room. For this reason, photographic storage is usually preferred for computerized storage and retrieval systems. Digitized information on magnetic tape is used in some instances, ~~but~~ Although most photographic storage is now on microfilm, newer systems with simpler processing proceedures such as Kalvar, ~~diazo processes~~ Actifilm, ~~thermo~~ photoplastic, and ~~PCMI~~ Photo Chromic Micro Image (PCMI) may also find a place. Storage may be in the form of sheets, cards, ~~and~~ or rolls of material.

(3). Searching involves two separate operations. First of all the required information must be located in the index, then it can be retrieved from ~~the~~ storage~~, system.~~ In a fully computerised operation the two steps are usually integrated The search might be conducted as follows: The author's name is entered using a typewriter, and all publications by that author are instantly displayed. Typing in the catalog number of the publication would cause the index to be displayed from which pages could be selected for scanning and printout. This closely follows the model of present library systems. Now consider an instance where the author or publication title were not known. The searcher would type in the name of a topic, and be given a list of sub-topics for review. Perhaps these would not adequately identify the kind of information sought so the searcher would refer to the computer thesaurus and try another topic name. This time the list of sub-topics allows the specific area of interest to be located, and a bibliography is presented which the searcher has printed out, since a large number of publications will need to be reviewed. Now he calls for abstracts on the most likely titles and eventually narrows the field to specific pages in a dozen or so publications for printout. Thus a library search which might have taken days or weeks can often be accomplished ~~in less than an hour,~~ or ~~even~~ in minutes. The Armed Services Technical Information Agency (ASTIA) now has eighteen million documents under computer

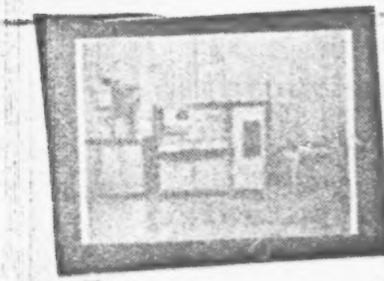
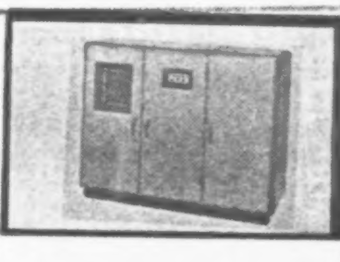
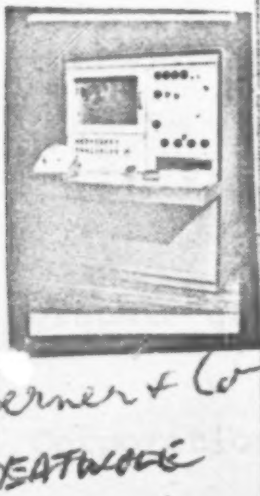
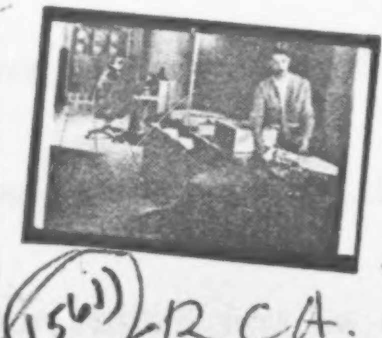
④. Retrieval is the process of removing the document from its storage location and presenting it to the viewer either as a display or by printing out hard copy. Since a computer is capable of satisfying the needs of a large number of users simultaneously, methods have been devised for storing images so that the computer is not idle while the researcher is scanning the display. This might involve electronic buffers or direct viewing image storage tubes, or some intermediate photographic medium such as microfilm, Kalvar, or PCMI. Whatever method is used, it should be almost instantly available for display, and suitable for making hard paper copy. Paper Printout is in some instances photographic, but is usually by electrostatic copiers or facsimile. Selected pages or whole books may be printed out by this method.

⑤. Selection of new documents, and their circulation to likely users are other areas being researched. Since the selection criteria for new documents cannot always be adequately defined, it may be some time ~~before~~ before automatic acquisition programs are feasible. However, worthwhile progress is being made in dissemination activities through use of automatic abstracting, ~~and~~ matching word profiles of publications against the interest profiles of readers, and automatically sending them abstracts pertinent to their interests.

6. Future development of information storage and retrieval systems using computers is closely related to cost, need, research, and technological innovation. There seems little doubt that such systems can meet requirements such as depth indexing, rapid access time, and simultaneously serving a large number of users. Use of television or teletype, or facsimile links to branch libraries should extend their usefulness, making it unnecessary to duplicate large and specialized libraries in any one area. ~~It~~ this might ~~also~~ make it possible for school libraries to have immediate access to any publication in a large city library.

A number of information storage and retrieval systems are now commercially available for those who can afford them. Avco (/) has an electronic file which stores ten million pages of information with one-second access time, electronic display, and electrostatic or facsimile printout. International Business [illegible] ha~~ve~~s completed a very large capacity system called Walnut for the Central Intelligence Agency, using modular image files which can be extended to 100 million pages. Access time is 5 seconds using Kalvar film for viewing and hard copy enlargement. FMA's FileSearch system uses edge coded 35mm microfilm which can be scanned at 6400 pages a minute to find codes which mat~~hcing~~ edge punched request cards. General Electric ( ) ha~~ve~~s built a complete storage and retrieval facility at the University of Southern Illionis for experimental purposes. Heatwole Associates ( ) ha~~ve~~s a small electronic information and data searching device. Houston Fearless ( ) ~~are~~ is developing a system for the AirForce having storage for up to 850 million documents by recording 850 pages on each of a million film chips. With just a single storage module, 8 million documents could be stored with an access time averaging ~~less than~~ ~~of the order of~~ five seconds. Information Retrieval Corporation is developing a Command Retrieval Information System for searching cartridge loaded microfilms. No

INFORMATION STORAGE & RETRIEVAL SYSTEM

|X ~~AVCO~~	|X ~~HOUSTON FEARLESS~~ ~~ABM~~	~~RABINOW~~	 (564). Teleregister
 (557) ~~ABM.~~ FMA FILESCARIA	|X? INFORMATION RETRIEVAL CORP	 (562) RECORDAK	
 GENERAL ELECTRIC (558) ~~ABM~~	|X? IBM	 NO. ~~(563)~~ (563) RECORDAK MINICARD	 COMPUTER CONTROL (556)
 (559) Herner & Co HEATWOLE	 MAGNAVOX (560)	 (561) RCA.	

computer is used for retrieval, but with over 500,000 images per cartridge electronic data processing equipment might be used to advantage for searching. Magnavox (560) has developed magnetic Magnacards for digital storage, and Magnavue cards for combined storage of digital and graphic information. Sorting, display, and printout are under computer control. Rabinow Engineering is developing an inexpensive magnetic tape unit for storage and retrieval of digital information. Recordak (562 & 563) developed a Minicard system of storage and retrieval for use by Eastman Kodak. This uses film chips (tiny pieces of 16mm film) containing digital data and multi-page storage, and is analogous in form to a microfilmed aperture card.

Mention should again be made here of General Electric's thermoplastic recording tape, and National Cash Register's Photo Chroic MicroImage (PCMI) recording materials, and also a new xerographic quick readout device being developed by the Xerox Corporation ( ). Many more innovations can be expected in the information storage and retrieval area in the near future.

COMPUTERS AND INFORMATION SYSTEMS

ACF Electronics Division
ACF Industries, Inc.
48 Lafayette St.
Riverdale, Md.

✓Addressograph-Multigraph Corp.
1200 Babitt Rd.
Cleveland 17, Ohio

✓Advanced Scientific Instruments
Minnesota 29, Minn.

✓Aeronutronics Division
Ford Motor Co.
Ford Rd.
Newport Beach, Calif.

Alden Research Foundation
Technical Publications Division
117 N. Main St.
Brockton, Mass.

All American Engineering Co.
DuPont Airport
Wilmington, Del.

American Systems, Inc.
1625 East 126th St.
Hawthorne, Calif.

Amp Incorporated
Harrisburg, Pa. (components)

Ampex Corporation
934 Charter St.
Redwood City, Calif.

✓Anelex Corporation
150 Causeway St.
Boston 14, Mass.

~~Applied Data Systems, Inc.~~
~~2300 Washington St.~~
~~Newton Lower Falls~~
~~Boston 62, Mass.~~

Applied Data Systems, Inc.
2256 Washington St.
Newton Lower Falls
Boston 62, Mass. (mobile service)

✓Applied Dynamics, Inc.
2275 Platt Rd.
Ann Arbor, Mich.

Arnox Corporation
9905 W. Jefferson Blvd.
Culver City, Calif.

Auto-Didactics
1912 Spruce St.
Philadelphia 3, Pa.

✓Autonetics Industrial Products Division
North American Aviation, Inc.
3400 E. 70th St.
Long Beach, Calif.

Autonetics
Division of North American Aviation, Inc.
3400 E. 70th St.
Long Beach, Calif.

Auto-Structor Corporation
790 Broad St.
Newark, N.J.

✓Avco Corporation
Electronics Division
2630 Glendale-Milford Rd.
Cincinnati 41, Ohio

✓The Bendix Corporation - see Control Data Corporation

✓Beckman Instruments
Berkeley Division
Richmond, Calif.

✓Benson-Lehner Corporation
14761 Califa St.
Van Nuys, Calif. Check

Bryant Computer Products
852 Ladd Rd.
Walled Lake, Mich. (components)

✓~~Burroughs Corporation~~
~~Electronics Division~~
~~Pasadena, Calif.~~

✓Burroughs Corporation
Equipment and Systems Marketing Division
392 West First St.
Dayton 2, Ohio

~~Burroughs Corporation~~
~~Second Ave. at Burroughs~~
~~Detroit 32, Mich.~~

✓California Computer Products, Inc.
8714 Cleta St.
Downey, Calif.

Clary Corporation
Computer Division
408 Junipero St.
San Gabriel, Calif.

✓Comcor, Inc.
5310 E. Pacific Place
Denver 22, Colo.

✓ Computer Control Co., Inc.
2251 Berry Ave.
Los Angeles 64, Calif.

✓ Computer Systems, Inc.
3021 West Clay St.
Richmond, Va.

Concord Control, Inc.
1282 Soldiers Field Rd.
Boston, Mass.

Consolidated Electrodynamics Corporation
360 Sierra Madre Villa
Pasadena, Calif.

Consolidated Systems Corp.
1500 S. Shamrock Ave
Monrovia, Calif.

✓ Control Data Corporation
8100 34th Ave. South
Minneapolis 20, Minn.

Data Processing Services
1336 Powhatan St.
Alexandria, Va.

Datex Corporation
1307 South Myrtle Ave.
Monrovia, Calif.

Daystrom, Inc.
Control Systems Division
4455 Miramar Rd.
La Jolla, Calif.

The Decker Corporation
45 Monument Rd.
Bala Cynwyd, Pa.

Digital Data Processor
2251 Barry Ave.
Los Angeles 64, Calif.

✓ Digital Equipment Corporation
146 Main St.
Maynard, Mass.

A.B. Dick Co.
5700 West Touhy Ave.
Chicago 48, Ill.

Digitronics Corporation
Albertson Ave.
Albertson, Long Island, N.Y.

✓ Donner Scientific Co.
Concord, Calif.

✓ Electrada Corporation
11244 Playa St.
Culver City, Calif.

Electro Scientific Industries, Inc.
7524 South West Macadam Ave.
Portland, Ore.

✓ Electronic Associates, Inc.
P.O. Box 2549
Long Branch, N.J.

Electronic Engineering Co.
231 Tyler Bldg.
Arlington Towers
Arlington 9, Va.

Electronic Engineering Co. of California
1601 East Chestnut Ave.
Santa Ana, Calif.

El-Tronics, Inc.
Alwac Computer Div.
13040 S. Cerise Ave.
Hawthorne, Calif.

✓ EPSCO, Incorporated
275 Massachusetts Ave.
Cambridge, Mass.
ESIAC — See EPSCO

Fairchild Camera & Instrument Corp.
Robbins Lane
Syosset, N.Y.

Fenske, Fedrick, + Miller Inc
12820 Panama St
Los Angeles 66, Calif.

FMA, Inc.
142 Nevada St.
El Segundo, Calif.

✓ Friden, Inc.
Product Planning
2350 Washington Ave.
San Leandro, Calif.

The Garrett Corporation
9851 South Sepulveda Blvd.
Los Angeles 45, Calif.

✓ General Dynamics Electronics
1895 Hancock St.
San Diego 12, Calif.

✓ General Electric Co.
Computer Department
13430 No. Black Canyon Highway
Phoenix, Ariz.

General Intellitronics Inc
900 Nepperhan Ave
Yonkers, N.Y

~~General Electric Co.~~
~~Light Military Electronics Dept.~~
~~Utica, New York~~

✓ General Precision, Inc.
GPL Division
63 Bedford Rd.
Pleasantville, N.Y.

~~General Precision, Inc.~~
~~Librascope Division~~
~~808 Western Ave.~~
~~Glendale 1, Calif.~~

GPS Instrument Co., Inc.
180 Needham St.
Newton, Upper Falls 64
Mass.

Graphic Calculator Co.
Hartford 1, Conn.

Harmon-Kardon, Inc.
Ames Court., N.W.
Plainview, New York (computers & digital logic)

Heatwole Associates
906 New Hampshire Ave., N.W.
Washington, D.C.

✓ Herner and Co.
1424 K. St., N.W.
Washington 5, D.C.

✓ Honeywell - see Minneapolis-Honeywell

Houston Fearless Corporation
Westwood Division
11801 Olympic
West Los Angeles, Calif.

✓ HRB-Singer, Inc.
396 Fifth Ave.
New York 18, N.Y.

✓ ~~Hughes Aircraft Co.~~
~~Vacuum Tube Products Division~~
~~2020 Short St.~~
~~Oceanside, Calif.~~

✓ Hughes Aircraft Co.
P. O. Box 90515
Los Angeles 9, Calif.

✓ H.W. Electronics, Inc.
14 Horon Dr.
Natick, Mass.

✓ IBM Corporation
590 Madison Ave.
New York 22, N.Y.

~~IBM Corporation~~
~~Data Processing Division~~
~~112 East Post Rd.~~
~~White Plains, N.Y.~~

✓ Informatics, Inc.
8535 Warner Dr.
Culver City, Calif.

Information Products Corporation
207 Bent St.
Cambridge 41, Mass.

Information Systems. Inc (see table

Invac Corporation
26 Fox Rd.
Waltham, Mass.

✓ Itek Corporation
Lexington 73, Mass.

International Telephone
and Telegraph,
Nutley, N.J.

Kollsman Instrument Corporation
60-08 45th Ave.
Elmhurst 73, N.J.

✓ Laboratory For Electronics, Inc.
LFE Computer Products Division
1079 Commonwealth Ave.
Boston 15, Mass.

Magnavox
Sales department
Fort Wayne, Indiana

Marco Industries Co.
207 South Helena St.
Anaheim, Calif.

Marquardt corp
16555 Saticoy St.
Van Nuys, Calif.

✓ Minneapolis-Honeywell Regulator Co.
2747 Fourth Ave. South
Minneapolis, Minn.

✓ Monroe Calculating Machine Co., Inc.
555 Mitchell St.
Orange, N.J.

✓ The National Cash Register Co.
Electronics Division
1401 East El Segundo Blvd.
Hawthorne, Calif.

✓ Packard Bell Computer
1905 Armacost Ave.
Los Angeles 25, Calif.

✓ Philco Corporation
Computer Division
3900 Welsh Rd.
Willow Grove, Pa.

Photocircuits Corporation
31 Seacliff Ave.
Glen Cove, N.Y.

Potter Instrument Co., Inc.
Sunnyside Blvd.
Plainview, N.Y.

✓ Rabinow Engineering Co.
7212 New Hampshire Ave.
Washington 12, D.C.

✓ Radio Corporation of America
Electronic Data Processing
Camden 8, N.J.

Radio Corporation of America
RCA Educational Service
Camden 8, N.J.

Raytheon Co.
40 Second Ave.
Waltham 54, Mass.

Recordak Corp
Wanamaker Place
New York 3, N.Y.

✓ Reeves Instrument Corporation
Roosevelt Field
Garden City, N.Y.

Remington-Rand Corp. See Univac

✓ Univac
Division of Sperry-Rand Corporation
1290 Ave. of the Americas
New York, N.Y.

Rheem Manufacturing Co.
400 Park Ave.
New York 22, N.Y.

✓ Scientific-Data Systems Inc.
1542 Fifteenth St.
Santa Monica, Calif.

Smith-Corona-Marchant, Inc.
410 Park Ave.
New York 22, N.Y.

Sperry-Rand Corp. See Univac

The Standard Register Co.
Dayton 1, Ohio

✓ Sylvania Electric Products, Inc.
Picture Tube Operations
Seneca Falls, N.Y.

Sylvania Electronic Systems
40 Sylvan Rd.
Waltham 54, Mass.

✓ Systron-Donner Corporation
888 Galindo St.
Concord, Calif.

TeleRegister Corporation ?

✓ Thompson Ramo Wooldridge
8433 Fallbrook Ave.
Canoga Park, Calif.

✓✓ Westinghouse Electric Corporation
3 Gateway Center
Box 2278
Pittsburg 30, Pa.

2

X

GAMING AND SIMULATION

~~I. INTRODUCTION~~

Gaming and simulation are quite ancient methods of teaching which involve role playing, decision making, and in the case of simulation, manipulative skills. Role playing develops new insights and understandings so that the learner is better prepared for the real situation should it ever occur. It is used in the school for teaching processes such as answering the telephone, or the operation of a grocery store. It is also used to dramatize problems for subsequent analysis, as with ~~say~~, for example, racial discrimination in human relations training. Gaming techniques differ from role playing in that the emphasis is on decision making, while in simulation it is necessary not only to make decisions, but to have certain physical skills to implement them.

The advent of the modern digital computer has allowed gaming and simulation to be carried on at a much more sophisticated level than previously due to its ability to rapidly process large volumes of data. Wherever the course of a game, or the reaction of a piece of equipment, has a mathematical or logical basis, it can be programmed on a computer for purposes of evaluation or control.

A. GAMING

1. PURPOSE

Gaming is used in management development programs, and by the military for teaching strategies. However, gaming is not simply a teaching tool. It is also useful to test ~~out~~ new procedures and practices before applying them in a real situation.

Gaming ~~is also useful~~ may help in selecting suitable personnel for a job, since in the real world academic skills are only part of the requirement; the ability to apply them is at least equally important. ~~Sometimes factors of~~ Negative personality factors or inability to work under stress ~~will also affect the suitability of a man for a job.~~ might also be detected in the gaming situation.

Gaming is ordinarily used for decision-making tasks which involve a large number of variables, so that there ~~are~~ may be many ~~perhaps a number of possible~~ solutions to the problem. Often a long history of similar problems allows the development of certain rules and even mathematical relationships between ~~certain~~ variables, so that a management game or war game can be evaluated in terms of such relationships. Since these "theories" of strategy for business or war are based on past occurrences they are likely to favor a conservative or traditional kind of solution. In reality, a departure from conventional practices may prove more successful. Nevertheless, gaming techniques do provide valuable experiences, and the modern digital computer allows rapid evaluation of the tactics used.

In a business game a company may be set up with certain assets, and the participants must develop ~~the~~ a company through capital investment, ~~development~~ introduction of new products, setting up a sales program, and so on. Since there are no real time limitations on the game, it might be possible to work through a two year program in three or four hours, and then use the computer to evaluate the proceedures used, the possible profits (or losses), and provide other relevant data. Certain important variables may have been overlooked in the game, just as ~~they~~ in real life, or unpredicatable variables might upset the course of action. A business theory may indicate a certain procedure will increase profits, but it cannot anticipate recessions, strikes, changes in buying habits, or the introduction of a rival product at more competitive prices. Hence, the theory is not immutable, unchangeable, and infallible, and will change in the course of time.

Gaming has motivational attributes for the learner since it is possible to evaluate the success of the venture when the experience is completed, or at intervals throughout the game. The modern computer allows highly complex mathematical theories to be used which employ a large number of variables. ~~so~~

that the experiences gained in the course of the game may approximate very closely ~~to~~ the results of applying those same decisions in a real situation.

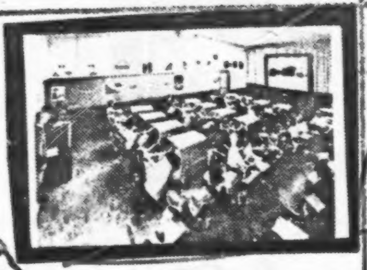
Gaming is little used for classroom teaching at ~~the~~ present, although a number of colleges and technical institutes have developed games, some with computer evaluation. As time goes on it is possible that gaming will become more important in the schools to teach decision-making, ~~along with~~ proceedures and principles of business, management, government, U.N. fund-raising, etcetera.

B. Simulation.

Where gaming is concerned with theories and principles, simulation is concerned with operational proceedures. A war game might involve only tactical decisions and strategy, but in simulated warfare a commando might have to cross mine infested territory among exploding shells, barbed wire, and booby traps. Simulation is the creation of an artificial environment which closely resembles the real environment so that its characteristics may be learned without the dangers and other consequences of the real life situation.

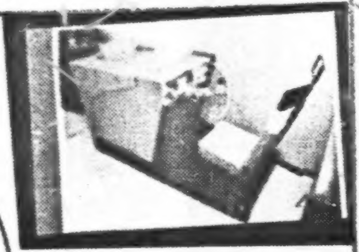
Simulation is widely used to teach skills involving man-machine relationships such as driving an automobile or an airplane. It is also useful for evaluating personnel under (simulated) operational conditions and to assist in the selection of new personnel. Simulation assists in designing new systems, and for learning to operate systems not yet built. For example, the Astronauts were subjected to vigorous training programs where conditions of high gravity, weightlessness, rapid deceleration, etc. were simulated on the ground. The equipment was likewise subjected to pressure, vibration, heat, and stress in simulated environments to insure its correct operation in flight conditions. The astronaut learned to operate the controls under simulated conditions so that by the time he made his flight, the capsule was operational, and he could fly it, even though man had never flown a Mercury capsule before!

Simulation is not limited to the space program. Schools are using DrivoTrainer units to prepare students for driving real automobiles, as shown in Fig. 567. Most aircraft pilots now learn to fly "on the ground" before they are entrusted to a multi-million dollar aircraft. Electronic



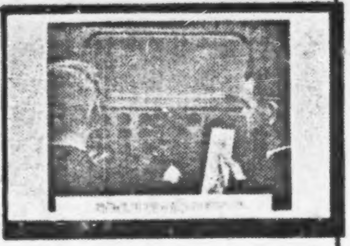
(567)

DRIVOTRAINER
(AETNA)

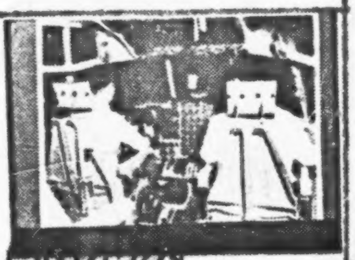


(568)

LINK

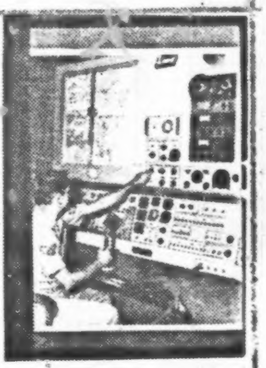


(569) LINK



(570) DC8 ?

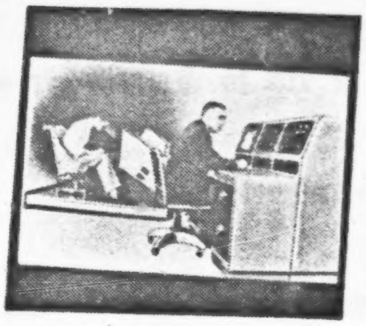
LINK



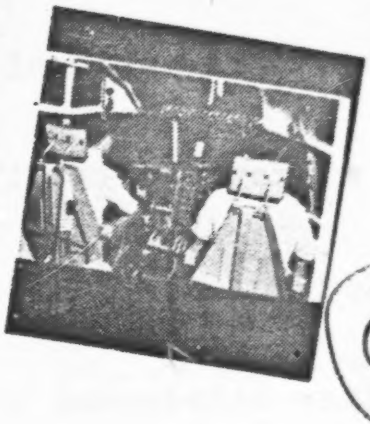
(571)

INSTRUCTORS
CONSOL LINK

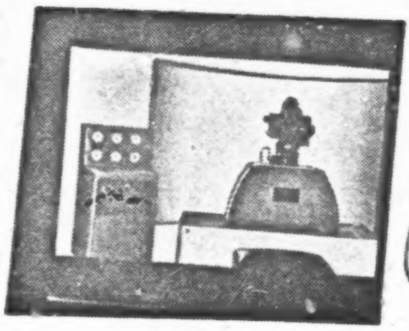
Mast
(578)



Mast
(579)

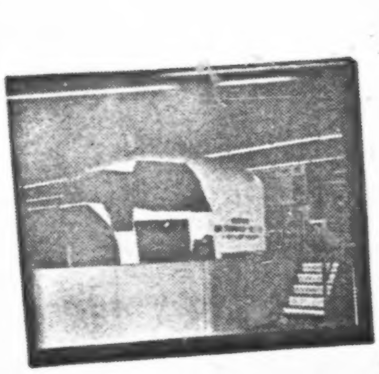


Link
(576) see
570



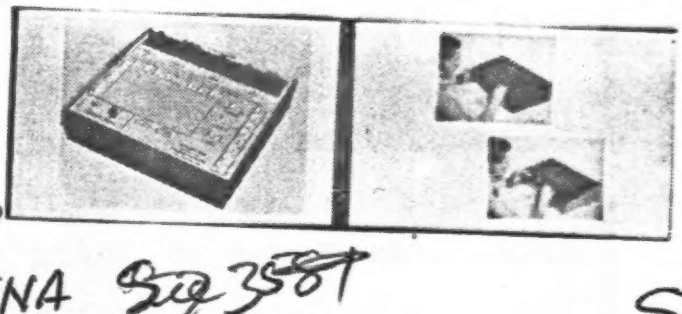
Mast
(580)

Gen. Precision
(572)



Link
(577)

?



(574)

AETNA See 358T

(575)

See 588
589

engineers learn trouble shooting in equipment where the problem is simulated rather than waiting for such a fault to occur in an operational piece of equipment. Computer operators learn first to use a small~~er~~ or simplified computer) before being entrusted with a multi-million dollar piece of equipment.

High fidelity simulation is that which closely approximates the real environment. In a high fidelity aircraft simulator, the trainee pilot is subjected to the pitch and roll, buffeting and vibration, and other conditions encountered in ~~associated with~~ the real aircraft. The sensation of take-off and landing is simulated through television projection on a model runway, and the appropriate tilting of the simulator cockpit. The "feel" of the controls and the instrument functions are simulated with precision. The plane will even run out of gas, catch fire, plunge out of control, or crash ~~behave like the real aircraft in a like situation~~ without danger to the pilot or equipment. Such high fidelity simulation has only been possible since the advent of computers.

41

Before continuing, it should be noted that in simulating the machine part of a man-machine system, the machine must respond as it would in a real situation. This implies the need to measure the real environment so that ~~the~~ the relevant characteristics can be built into the simulator. In any form of simulator training the learner is continually interacting with those elements of the machine or the environment which he must learn. Simulation may be defined as the creation of a responsive machine or environment to teach skills involving objects, actions, and information ~~through~~ whi~~ch closely approximates the real life situation~~.

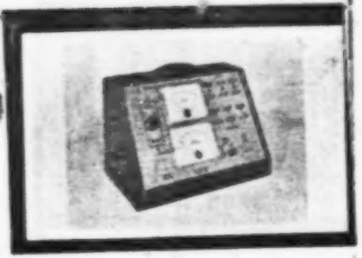
Simulation is useful for developing systems where several persons must co-ordinate their activities. The dress rehearsal of a play is ~~like~~ a "simulation" of the actual performace, ~~and~~ while several "dry runs" may be needed to coordinate the various activities involved in the firing of a missile. In systems involving complex man-machine relationships a computer may be needed to simulate the machine functions in these "dry run" or training activities. The complex ~~battlefield~~ displays used in battlefield control systems mentioned earlier (p may be combined with a war game for training purposes. Here the personnel can learn operational procedures with a game in preparation for a real war situation. Notice that this application has elements of both gaming and simulation combined.

II. ~~TRENDS AND DEVELOPMENTS SINCE 1955 1955.~~

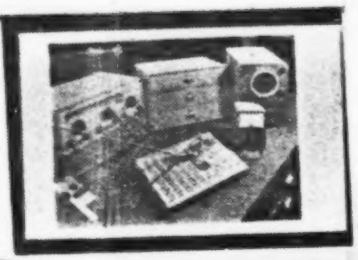
There has been a marked development of electronic~~s~~ simulators for use in schools over the past few years, and also a number of excellent kits and toys have become available which involve simulator functions. Electronic~~s~~ trainers for building up units of equipment have been marketed by Paromel (587), Philco (/), and Radio Corp. (/). Devices for electronic trouble shooting ~~purposes~~ have been introduced by Link (585), ______ (586), and others. There is a wide variety of computer simulators, most of which are simple computer units, and these vary from twenty dollar kits to units costing thousands of dollars. Typical examples are those manufactured by ~~Aetna~~ Athena ( ), Epsco ( ), Jantzen ( ), ~~( ) Philco ( )~~ Link ( ), Paromel ( ), Scientific Education ( ) and Universal Scientific ( ).

(585) LINK

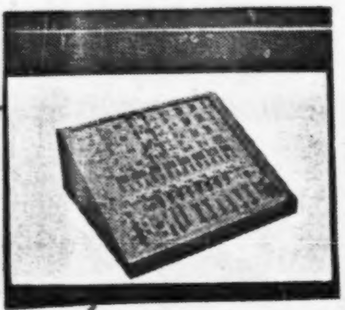
Dricut.



(586)



(587) Paromel.



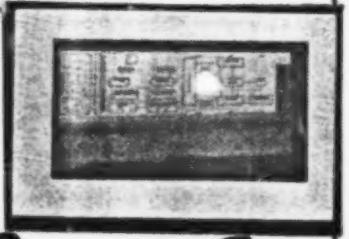
(583)

Epsco

~~AETNA~~

Athena Scientific

(581)



Computer Control

(582)

(584) JANSEN

? Scientific Educ Products.

(588)

UNIVERSAL SCIENTI

(589)

Simulators are more often used for complex operations than simple ones since it is less expensive to train personnel on a simulator than using the actual equipment. Sometimes the simulator is used to teach a single task or function; in other instances the simulator might involve a whole system of operations. Such simulators might include operating a helicopter or reading a radar scope, and the majority of those presently operational have been developed for military or civil defense purposes. [illegible] ( ) used a simulator to practice [illegible] a helicopter over stationary and moving targets, but also a radar [illegible] tool for simulation [illegible] in three climates and to train a [illegible] radar scope simulator [illegible] for targeting [illegible] simulator in the [illegible]

(540) SDC

> Five [illegible] radar scope. There is a [illegible] clutter, [illegible] targets, [illegible] and similar display characteristics of an operating radar scope.

[illegible] also [illegible] a wide variety of simulators involving radar navigation and target recognition, [illegible] and [illegible] general application include

Simulators are more often used for complex operations than simple ones since it is less expensive to train personnel on a simulator than using the actual equipment. Sometimes the simulator is used to ~~train~~ teach a single task or function; in other instances the simulator might involve a whole system of operations. Task simulators might include hovering a helicopter or reading a radar scope, ~~and~~ The majority of ~~these~~ simulators presently operating have been developed for military or civil defense purposes. Mast (578) has a simulator to practice hovering a helicopter over stationary and moving targets, and also a sight manipulation test for simulating aircraft moving in three dimensions to train gunnery operators. The Mast radar scope simulator (579) for target recognition and pursuit for night fighters is quite elaborate in the means used :

> Five 300 watt projectors are trained on the phosphor coated screen to produce the radar image. These in conjunction with a system of shutters, blinkers, filters, and servo controlled reticules simulate targets, chaff, clutter, ziggle, band, and similar display characteristics of an operating radar scope.

Marquardt also manufactures a wide variety of simulators involving radar navigation and target recognition, gunnery radar, and visual flight bombsight. More unusual applications include x

MAST
See earlier

(591) USI
ROBODYNE

[illegible] and the [illegible]

[illegible]

[illegible]

[illegible]

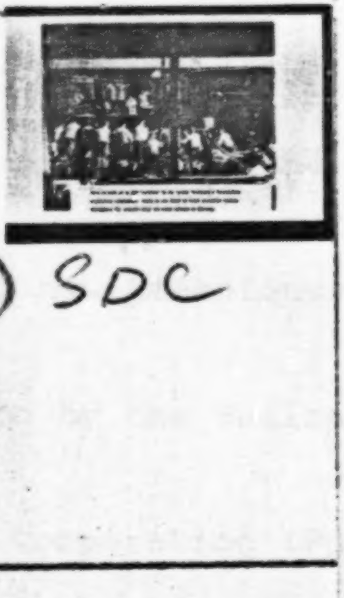
[illegible]

It may be noted that [illegible] simulation [illegible]

[illegible] all [illegible]

of the [illegible] as well as of their

individual [illegible]



(590) SDC

[illegible] of [illegible]

[illegible] is one of [illegible] in traffic control are

being tested [illegible] by the National Bureau of Standards

and the System Development Corporation (SDC). Simulations of

[illegible] simulated on a [illegible]

by the National Bureau of Standards. In developing new systems of

this type, predictions must be made of the probable increase in

traffic which will occur by the time the system is operational,

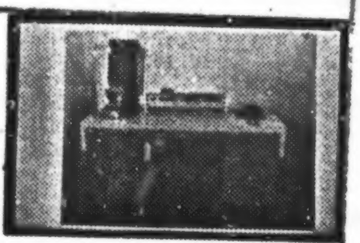
and [illegible]

flying low over land masses at supersonic speeds, and the piloting of space vehicles.

All of the major aircraft companies build simulators for training pilots, including Boeing, Convair, Douglas, Lockheed, Link, Minneapolis Honeywell, and North American.

It should be noted that flying an aircraft is no longer a one-man operation; therefore, many simulators have positions for all members of the crew so that the crew can train as a unit as well as in their individual tasks.

Because of problems created by the increase in air traffic flow in and out of airports, new techniques of traffic control are being tested using simulation by the National Bureau of Standards and the Systems Development Corporation (Fig. 590). Problems in designing new freeway systems are also being simulated on a computer by the National Bureau of Standards. In developing new systems of this type, predictions must be made of the probable increase in traffic which will occur by the time the system is operational, and the different characteristics

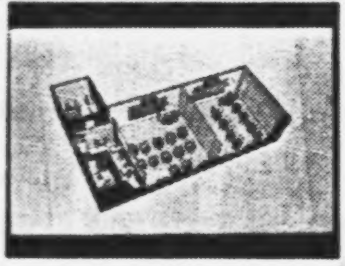


(592) LOCHHEED

45

tics of the planes or ~~cars~~ automobiles that will be used in that future era.

The psychomotor trainers for key punch operation and typing mentioned in the chapter on teaching machines (P.) are ~~really~~ a special type of simulators, since problems are simulated on the device in order to teach its operation. It should be noted that these also incorporate a capability not required of a simulator, which is the ability of the machine to adapt the level of difficulty of the problems to the competency of the learner. In an aircraft simulator, for example, ~~you~~ one faces the real situation and there is no compromising. If an error is made ~~you have to~~ the pilot must correct it or the plane will crash. It is possible however to use the computer which simulates the behavior of the aircraft to gather information on the performance of the operator, and even to present him with additional problems or experiences in areas where further practice is needed. Such possibilities have been implemented by Lockheed (59) and Minneapolis Honeywell ( ).



(593) SDC?

(594) ?
Oregon

C. Psychological Simulation.

Simulation is widely used as a laboratory device to observe a model of a system in action. The performance of a new aircraft at supersonic speeds can be studied using a model in a wind tunnel. The actual performance of an oil refinery can be studied using a scale model. Similarly, the operation of the human brain can be studied using a computer to simulate its various functions. The brain and the computer have several features ~~xxxxxxx~~ in common: both have inputs and outputs used to communicate with the outside world; both exhibit storage and data processing functions. However, the mechanisms by which these functions are achieved are very different. The brain is a biological organism while the computer is an electronic device. Despite their similarity in function, their difference is probably as great as the means of locomotion by foot ~~used in walking~~ and in an automobile. The computer is nevertheless useful for theoretical studies where it serves as a model or simplified version of the human thinking mechanism.

In the process of tutoring (programming) the computer to understand (interpret) the English language, much is being learned about the structure of the ~~English~~ language, and the very involved process by which people ~~we~~ learn. Since a computer comes with no learning and no intelligence of its own, it is necessary to start with the most fundamental learning processes and information. It has been discovered that two kinds of learning mechanism are needed; one which learns by association with similar objects or experiences, and one which simply remembers a series of unrelated phenomena, as with the digits of a telephone number. It has been necessary to tutor the computer in the elements of language including words, ~~and~~ sentence structure, tense, ~~and~~ meaning, vocabulary ~~and interpretation~~.

Computers have been taught to solve problems, to be self programing, and to learn from their mistakes. The various levels of ~~higher~~ mental activity ~~processes~~ have been simulated in computers which play chess, checkers, and poker. These programs differ~~s~~ from those used in business and war games in that the emphasis is not on developing an exact mathematical evaluation of a real situation ~~xxxx~~ so much as to study the mechanisms involved in solving a ~~new kind of problem.~~

new kind of problem. It is hoped through psychological simulation to develop new insights into the mechanisms involved in learning, in problem solving, ~~and~~ in insight and intuition. It is also hoped to learn something about the organization of subject matter and modes of presentation to the student. Present indications are that this new field will be very fruitful, and will have enormous implications for future educational systems.

The feasibility of the computer to display intelligent behavior has been widely speculated upon. ~~and it is not yet possible to predict how far such developments can go. Edmund Teller at a recent computer convention^x stated that the principal difference between the computer and the human brain was that the computer had very limited storage capacity.~~ The chess and checkers programs enable a computer to think at the level of a novice player, ~~and~~ How far this can be extended with electronic techniques has yet to be ~~xxxxxxxxx~~ determined. This whole area is the subject of much speculation. ~~and [illegible]~~

his needing ~~to ask for it!~~

The implications for schools and colleges are enormous, ~~although the fruits of these developments lie in the distant future.~~ First~~ly~~, much is being learned about the structure of language from the computer studies, ~~and this~~ which will influence the means by which language is taught, and perhaps even result in minor changes from the present form. Secondly, the facility of translation will bring other cultures much closer to us than ever before. Third, the teaching of foreign languages might be subjected to supervision by a computer since it can monitor every response of each student, just as it would in a teaching machine. And fourth, the ~~kinds of~~ capabilities being developed for translation ~~programs~~ suggest ~~means~~ ways by which meaning might be analyzed so that new information could be added to an information system, ~~while~~ and redundant information ~~could be~~ eliminated. In this way, textbooks could be automatically rewritten and up-dated ~~by the computer;~~ teaching machine and language programs could be modified to meet the special needs of individual students, and so on. ~~The feasibility of the~~

~~in cost.~~

~~The possible advantages to our economy and standard of living are obvious, but~~ T the implications from an educational point of view need detailed study. If there are less jobs available for people of minimal intelligence and training, then it is essential that the overall standards of education be raised. Present experiments with computerized teaching machines, particulary those performed ~~for~~ by Omar ~~Kyam~~ Khayyam Moore for the ~~Thomas~~ Mc Graw-Edison Research Laboratories, indicate that even the feeble minded can be much more usefully educated than at present so that, ironically, if the computer creates a problem by eliminating the jobs of the less intelligent, it might also be instrumental in helping to solv~~ing~~e that problem by ~~raising the standards~~ increasing the quality of education!

~~5. Simulation, gaming, and research. The computer is the controlling mechanism behind many experiments involving simulation and gaming, and since this field is already having a considerable impact on education, it is relegated to the chapter which follows so that it can be studeid in greater detail.~~

ELECTRONIC TRAINERS & SIMULATORS

✓ Athena Scientific
2216 Hill St.
Santa Monica, Calif.

Aetna

Audio Products
Camden 2, N.J.

Berkeley Enterprises
815 Washington St.
Newtonville 60, Mass.

Burtek, Inc.
7041 E. 15th St.
Tulsa, Okla.

✓ Computer Control Co., Inc.
Old Connecticut Path
Framingham, Mass.

Convair

Drivotrainer – see Aetna

Epsco

Daystrom, Inc.
4455 Miramar Rd.
La Jolla, Calif.

Douglas

✓ General Precision, Inc.
Simulation & Control Group
Link Division
Binghamton, N.Y.

International Communications Foundation
870 Monterey Pass Rd.
Monterey Park, Calif.

I.T.T. International Electric Corporation
P.O. Box 285
Paramus, N.J.

✓ Jansen Electronics Manufacturing, Inc.
2285 University Ave.
St. Paul 14, Minn.

Link Division, See General Precision –

✓ Marquardt Corporation
Room 210
1729 H. St., N.W.
Washington, D.C.

✓ Mast Development Co.
2212 E. 12th St.
Davenport, Iowa

North American Aviation
Columbus Division
4300 East Fifth Ave.
Columbus 16, Ohio

Paromel Electronics
3956 Belmont Ave.
Chicago 18, Ill.

Philco Technological Center
"C" and Ontario Streets
Philadelphia 34, Pa.

Philmore Manufacturing Co., Inc.
130-01 Jamaica Ave.
Richmond Hill 18, N.Y.

Radio Corporation of America
Telecommunication Center
Meadow Lands, Pa.

Rockwell Manufacturing Co.
400 N. Lexington Ave.
Pittsburgh 8, Pa.

Science Electronics, Inc.
195 Massachusetts Ave.
Cambridge, Mass.

Scientific Educational Products
101 W. 31st St.
New York, N.Y.

✓ Universal Scientific Co., Inc.
1312 South 13th St.
Vincennes, Ind.

USI Robodyne

The School of the FUTURE
a Summary

~~Start Chapter Here~~

A visit to a school ten years from now will show many changes. Many of the classrooms will be windowless to facilitate proper light control. There will be several large "lecture theatres" for group presentations ~~and~~ including television film, slide, and overhead projection. The teacher will have full control of lighting, sound, and ~~all presentation~~ equipment ~~built into as part of~~ from the rostrum. There will be more than one projection screen so as to facilitate ready comparison of related materials, and allow illustrations to be presented alongside ~~of~~ schematics and graphs, or enlarged sections to be viewed ~~along~~beside the materials from which they were derived. Projection may be from the back of the auditorium or rear screen. ~~depending~~ There will be some classrooms of the conventional size, and many for smaller groups. These also will be equipped with light control and a ~~whole~~ complement of equipment so that instructional tools will always be immediately available as required. And there will be scores of private study booths, often equipped with listening and viewing devices.

There will be a variety of laboratory situations in addition to science labs and workshops. These will include a reading lab associated with a reading clinic; a listening or electronic learning lab, perhaps several, teaching a wide range of ~~subjects involving~~ including foreign lang spoken language skills. These will differ from present language laboratories in the degree of automation involved, having ~~greater flexibility,~~ including light control, and air conditioning full facilities for film and television projection. In some instances individual audio-visual viewing units will be used, and in others group response systems will become a part of the

~~laboratory.~~ environment.

There will also be rooms, perhaps laboratories, containing a variety of different teaching machines and programed texts, and there will be similar facilities as part of the library. The school library of the future will be very different. Vending machines will supply books and automatically record information on the borrower from a credit card. College lib^raries will ~~xxxxxxxxxxxxxxxxx~~ use computers for some specialized areas, and vending machines for books in constant use. Where a computer exists, it will ~~also~~ slowly supplement or replace the card catalog, even before it becomes a means of storing documents. ~~A Facsimile link will provide additional resources from~~ Communication links with key libraries throughout the country will allow facsimile copies of books and ~~thases~~ theses to be produced almost instantly on demand. Also, the library will become a repository for many other materials besides books - films, filmstrips, magnetic tape and disc recordings, - and will aquire additional facilities for listening, viewing, and study using language lab and teaching machine techniques.

The learning space will be more flexible than it has even been before. Folding Sound proof partitions will ~~be a common feature so that~~ to permit large rooms to ~~units can~~ be broken up for small group activities. Many schools will be built in modular units to ~~xxxxxxxxxx~~ allow for expansion and re-arrangement as reqqired. Short term needs will be met by ~~traiber~~ trailer classrooms and laboratories complete with their own lighting and air conditioning.

Schools will be more adequately provided with storage space. Air conditioning, temperature control, and lighting control will be ~~considered a must.~~ an integral part of the learning environment. Rooms will be acoustically designed and treated to insure listening ease and comfort. School furniture will ~~also change somewhat so that it is~~ be more functional, more comfortable, and correctly designed fob the age group ~~which~~ who will use it.

Schools will operate the year round, and sponsor adult classes in the evenings to make maximum use of the facilities.

Much more will be known about the learning process than was ever known before, so that instruction as a whole will be more efficient and systematic. The teacher will choose instructional tools to suit the specific purpose~~,~~ instead of attempting to meet all situations with lectures and library books. Learning experiences will be no more abstract than they need ~~have~~ to be; in every instance the best communication device available will be used.

And among the more conventional materials of instruction there will be some startling changes. Text books will be subjected to the same rigorous scrutiny required of programed texts to insure that they adequately communicate the required content. Computerized ~~forms of~~ type-setting will facilitate rapid updating of textbooks ~~information at minimal cost,~~ and ~~also~~ the preparation of special editions to meet local needs, ~~(for example, a geography book for use in California would be expected to have a greater emphasis on California than a similar text used in Florida).~~

595
Micro miniaturization

There will be marked changes in curricula and, ~~to meet modern needs.~~ Wherever possible, standardization will have been effected to minimize the problems of our migrating population. In an era where many ~~most~~ families move every six ~~five~~ or seven ~~six~~ years to follow ~~as required by~~ the job, it is unrealistic to insisted that the needs of any one area are so different to all other parts of the United States.

New concepts in communications will open up a ~~whole~~ host of new possibilities. The laser, with an information carrying capacity thousands of times greater than a television frequency will make it possible to send the contents of a book, or a transcription of a television program, across the country in a fraction of a second.

Computers will be highly significant for processing information. ~~The modern computer opens up an even wider range of possibilities.~~ Imagine a library dredged of redundant ideas, and indexed in depth using a wide range of locators ~~parameters~~. The knowledge of the world could be instantly available to scholars and researchers through this most marvellous tool.

It cannot be anticipated that learning in the future will require any less effort than it has in the past, but it is hoped that by higher organization of ~~both~~ content and more effective methods of communication, ~~presented~~ ~~the way in which that content is communicated~~ to ~~the student,~~ ~~that~~ learning will at least be more efficient that at present. A better understanding of individual needs and use of adaptive tutorial methods to meet these meeds should improve the ~~result in better~~ performance at ~~from~~ the individual student. By How much ~~better~~ is impossible to anticipate. We presently have techniques which will increase learning by 5%, 10%, 20%. Potential breakthroughs may increase this. However, even by judicucous combination of existing methods it would be feasible to increase learn~~x~~ing up~~t~~ to 50% through technology alone ~~The use of better teaching tools and materials, and better trained teachers.~~ The unfortunate fact is that to implement this know-how will require an unprecedented investment in our educational system. It comes back to the situation mentioned in Chapter 2. Thirty years ago we could hardly envisage the need for freeways, or justify their cost. The freeways to learning are perhaps as remote to ~~modern~~ our present civilization as were freeways for automobiles thirty years ago, but now is the time when we must start planning for them. ~~Our present~~ The educational system does not go near to meeting ~~our modern~~ present let alone future needs. Many subjects taught in college could easily be seconded to high school curricula if ~~only~~ more could be taught at the elementary ~~or~~ high school level. Technology has made a break-through in the field of communications through the introduction of visual teaching techniques, through the use of pre-prepared materials in the form of ~~xxxx~~ filmstrips and recordings and motion pictures and kits. It has provided a variety of presentation media. It has devised tutorial methods + media which are practical and economic. And it has provided means of evaluation not hitherto possible.

Schools may be bound by tradition, limited by finance, and ill equipped ~~xxxx~~ to meet the needs of the present day world. But ~~probably~~ education may well be ~~is~~ more important than rockets and space ~~xxxx~~ capsules and atom bombs in determining our ultimate survival. Automation is pointing the finger at the inability of education to adequately provide for the less intelligent members of our society, yet Experiments with computers and highly sophisticated teaching machines are proving that ~~we do have the means at our disposal to improve~~ much more can be done even the ~~lesser endowed members of our group~~ with sub normal student. The question remains whether the necessary interest and planning and investment will go into education, or whether ~~the future of the modern world will become lost in outer space.~~ a national crisis will be necessary to achieve ~~the~~ sufficient ~~necessary~~ public support.

VENDING MACHINES

Automatic Canteen Co. of America
Canteen Division
18900 Susana Rd.
Compton, Calif.

Educational Machines Corporation
9350 Roselawn Ave.
Detroit 4, Mich.

Harcourt Outlines
Milroy, Ind.

International Match

The Vendo Co.
7400 E. 12th St.
Kansas City, Mo.

School architecture

- Flexible space
- modular units
- trailer labs

- new concepts of plumbing
    - power needs and supply
    - air conditioning and environmental control
    - light control
    - interior lighting
    - acoustic conditioning
    - intercom, telephone, etc
    - provison for a-v equipment
    - provision for the new technologies of teaching such as televsion, response devices, teaching machines
    - storage facility

School Furniture

- comfort
- functional design
- provision for equipment and newer technologies
- single use or multi-purpose furnishings
- the study corner
- the study booth